(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 319 131 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of patent specification: **30.12.92** (51) Int. Cl.[5]: **B65B 1/36**, B65B 43/60

(21) Application number: **88309290.0**

(22) Date of filing: **06.10.88**

(54) Powder filling machine.

(30) Priority: **07.10.87 GB 8723559**

(43) Date of publication of application:
07.06.89 Bulletin 89/23

(45) Publication of the grant of the patent:
30.12.92 Bulletin 92/53

(84) Designated Contracting States:
AT BE CH DE ES FR GB GR IT LI NL SE

(56) References cited:
FR-A- 1 562 251
US-A- 2 907 357
US-A- 3 656 517

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Description

This invention relates to a powder filling machine, by means of which a succession of containers receive a quantity of powder from a bulk supply thereof.

A known powder filling machine is shown diagrammatically in Figures 1 and 2 of the accompanying drawings, Figure 1 being a side elevation and Figure 2 being a vertical section showing the machine in a direction at right angles to Figure 1.

The machine shown in Figures 1 and 2 comprises a filling wheel 2 rotatable about a horizontal axis by means of a horizontal shaft 4. The circumference of the filling wheel 2 has a plurality of radially extending ports 6, of which only two are shown in Figure 2. Each port 6 has a piston 8 which, with the wall of the port 6, defines a chamber 10. The size of the chambers 10 can be altered by sliding the pistons 8 inwardly or outwardly in the ports 6. A hopper 12 is positioned immediately above the filling wheel 2 and contains a supply of powder. Below the filling wheel 2 is a conveyor mechanism, represented diagrammatically by line 14, which presents a succession of containers 16, of which one is illustrated, immediately beneath the filling wheel.

In use, a supply of powder is placed in the hopper 12 and is stirred throughout the process described below to maintain a homogeneous mix. The filling wheel 2 is rotated by the shaft 4 with an indexing motion. As each chamber 10 is positioned below the hopper 12 a predetermined volume of powder is drawn into the chamber to form a plug of powder therein, by the application of vacuum to the chamber. The means for applying vacuum are not shown. The amount of powder drawn in depends on the volume of the chamber which, in turn, depends on the position of the piston 8. The powder continues to be held in the chamber under vacuum until it reaches a position where it is vertically above the container 16 to be filled. At this point air, nitrogen or carbon dioxide, for example, at a little above atmospheric pressure is applied to the chamber to expel the powder into the container. The emptied chamber then continues its indexing motion back to the hopper. One modification of the system just described is to hold each container 16 in position below the filling wheel for long enough to receive a plurality of plugs of powder by discharge from a corresponding plurality of chambers. This makes it possible to use the same machine for filling containers with a wider range of fill weights or volumes. One use for the powder filling machine just described is in introducing pharmaceutical materials, for example ranitidine, into containers. The volume of such containers is typically from 8 ml to 127 ml, and the weight of powder to be introduced is in the range of from 1/4 to 10 g or more, for example 350 or 450 mg; ideally in one shot.

The known machine just described uses, as has just been mentioned, a filling wheel which rotates with an indexing motion. This gives rise to a number of disadvantages. One of these is that the speed at which the wheel can rotate is necessarily much less than the speed at which it could rotate were it doing so continuously. As a consequence, the number of containers which can be filled per unit time is considerably less than the number which could be filled were the machine not rotating with an indexing motion. Also, the indexing motion requires a sophisticated timing mechanism to ensure that a container is correctly positioned with respect to a chamber at the moment when powder is being discharged from the chamber. The necessity for such a timing mechanism gives rise to the possibility of error, and in any case increases the cost of the machine.

Examples of such known filling machines are disclosed in US Patent No. 4,640,448 (TL Systems Corporation), German Published Application No. 31 20 017 (Zanasi Nigris S.p.A.) and US Patent No. 4,671,430 (Eli Lilly and Company)

US Patent No. 3,656,517 (Perry Industries Inc.), which forms the basis for the first part of claims 1, discloses a powder filling machine in which a horizontal filling wheel rotates with an indexing motion, powder being sucked into chambers in the filling wheel by means of vacuum. Containers to be filled are fed to the filling wheel along a linear path.

US Patent No. 3,565,132 (Phone Poulenc S.A.) discloses a powder filling machine with a horizontal filling wheel rotated continuously above a turntable for the containers. Powder is delivered to the containers via radial grooves in the filling wheel by means of cam-operated doctor blades.

British Patent No. 2094267 B (IMA-Industria Macchine Automatiche SpA) describes a machine for feeding predetermined quantities of tea and the like onto a web of filter material to form tea bags. The tea is fed from a generally horizontal filling wheel having recesses which are filled with the tea by means of plungers.

US Patent No. 2,907,357 (American Cyanamid Company) discloses a powder filling machine for bottles wherein a powder measuring roll rotates about a horizontal axis and feeds powder to a funnel plate rotating about a vertical axis. The funnel plate comprises a plurality of funnels arranged above a plurality of bottles which are carried about an axis colinear with the funnel plate axis.

It is an object of the present invention, in at least some aspects thereof, to provide a machine which eliminates or mitigates the above disadvan-

tages and can advantageously be used in sterile powder filling operations.

Accordingly, the present invention provides a machine for introducing a quantity of powder into a plurality of containers, comprising a powder transporting member mounted on a substantially vertical axis and having a plurality of downwardly open chambers, a container transporting member located below the powder transporting member, means for continuously rotating the powder transporting member about the substantially vertical axis, a reservoir for powder with which the said chambers communicate during part of the rotation of the powder transporting member, means for applying vacuum to the chambers to cause powder to be drawn therein, and means for discharging the powder from each chamber into a container carried by the container transporting member,

characterized in that the container transporting member is mounted on the same substantially vertical axis as the powder transporting member for continuous rotation therewith, that the reservoir is located at least in part between the powder transporting member and the container transporting member, that a plurality of the chambers of the powder transporting member communicate at any one time with the reservoir along an arcuate communication path, that the powder transporting member is mounted on the substantially vertical axis for rotation in a single, substantially horizontal plane, and that means are provided to deliver and remove containers to and from the container transporting member either side of the reservoir.

Preferred embodiments of the present invention are described in detail below, by example only, with reference to the accompanying drawings, wherein:

Figures 1 and 2 are views showing a known powder filling machine, as already described;

Figure 3 is a diagrammatic vertical section showing an embodiment of the present invention;

Figure 4 is a horizontal section showing part of the machine of figure 3 and the powder reservoir;

Figure 5 is a similar view to figure 4, showing in detail the powder reservoir;

Figure 6 is a perspective view of a hopper which can serve two filling wheels;

Figures 7 and 8 show respectively two filling wheels which may be used in a further embodiment of the invention;

Figures 9 to 11 are plan views showing details of the embodiments of figures 3, 7 and 8; and

Figure 12 is a diagrammatic plan view of a further embodiment of the invention.

The embodiment shown in Figures 3 to 5 comprises a filling wheel 20 having an upper plate 22 and a lower plate 24 both secured to a shaft 26 for rotation by the shaft about a vertical axis. Adjacent its circumference the lower plate 24 carries a plurality of upstanding cylinders 28, and the upper plate 22 carries a corresponding plurality of downwardly extending pistons 30, each piston 30 being received within a respective cylinder 28. The pistons 30 each comprise a tube 32 made of a material such as stainless steel, closed at the lower end by a barrier 34 of sintered stainless steel, i.e. a material which is permeable to air but impermeable to powder. Alternatively, the barrier 34 may, for example, be made of nylon or a woven wire cloth. The space defined within each cylinder 28 below the barrier 34 constitutes a chamber 36 for receiving powder. In a preferred form of the wheel 20 there may be twenty-four chambers 36.

An annular plate 38 is mounted stationarily above the upper plate 22 in such a manner that the upper surface of the plate 22 is in sliding contact with the lower face of the plate 38. An arcuate channel 40 is formed in the lower surface of the plate 38 and is in communication via ports 42 in the upper plate 22 with the interior of those pistons 32 which are located below the arcuate channel 40. The channel 40 communicates via a bore 44 with a source of vacuum. The plate 38 has a further channel 46 which communicates via one of the ports 42 with the interior of one of the pistons 30. The extent of the channel 46 is such that at any given moment only one piston 30 is in communication with the channel 46. The channel 46 communicates via a bore 48 with a source of air at above atmospheric pressure.

The configuration of the channels 40 and 46 are described in more detail further on in the description.

The upper end of the shaft 26 carries a screw thread 50 on its outer surface, and this is in threaded engagement with a corresponding screw thread on the inner wall of an adjustment member 52. The member 52 has a lower annular portion 54 the lower surface of which is in sliding contact with the upper surface of the plate 38. By rotating the adjustment member 52 the plates 22 and 38 can be raised or lowered. This alters the relative positions of the cylinders 28 and pistons 30, thus altering the size of the chamber 36. A compression spring 55 urges the plates 22 and 24 away from one another. Whatever the position of each piston 30 with respect to its cylinder 28, air-tight contact therebetween is maintained by an O-ring seal 56. Rotation of the shaft 26 with respect to the stationary plate 38 is permitted by the provision of a ball race 58 or other bearing structure.

As an example, if the diameter of each chamber 36 is 10 mm, the length of the chamber may be adjustable between 3 mm and 40 mm.

Volumes of the chamber range from approximately 85 to 3142 mm^3 (i.e. lengths of from 3 mm to 40 mm if the diameter is 10 mm). Preferably the volumes of the chamber range approximately up to 1571 mm^3 (i.e. lengths approx 3 mm to 20 mm if the diameter is 10 mm).

A container transporting member in the form of a magazine 60 is located below the wheel 20. The magazine takes the form of a generally circular disc which is secured to a continuation of the shaft 26 for rotation therewith. Thus, wheel 20 and magazine 60 rotate in unison with one another. The magazine 60 carries, in use, a plurality of vials 62 or other containers in notches around its circumference. Empty vials are brought to the magazine by a conventional conveyor, for example a scroll conveyor, so that each vial is located immediately beneath a respective chamber 36. As the wheel 20 and the magazine 60 rotate in unison with one another the vials continue to be located beneath their respective chambers until the filling process, described below, is completed, at which point the vials are removed from the magazine by another conveyor (not shown) which may also be of a conventional construction.

The feeding of the vials 62 to and from the wheel 20 is shown in Figure 4. The vials 62 rotate with the filling wheel around approximately 240° before being removed, having been filled with powder.

A powder reservoir is provided in the form of a hopper 64 which is located to one side of the structure described thus far. If desired, the structure described above may be duplicated on the opposite side of the powder hopper 64, so that a single hopper serves two filling wheels. This effectively doubles the capacity of the machine. A hopper 64' appropriate for serving two filling wheels is shown in Figure 6. The hopper 64 has a foot portion 66 of larger diameter than its body portion, the portion 66 extending below part of the wheel 20. In the case of hopper 64' two portions 66' are provided, on diametrically opposite sides of the hopper.

Stirrer paddles 68, shown by way of example in Figure 5 as being cruciform in shape, rotate in the hopper portion 66 to maintain a homogeneous powder mix therein.

The hopper portion 66 has an arcuate opening 70 so located that at least one of the chambers 36 is in communication at any given time with the interior of the hopper. The hopper 64' has two arcuate openings 70'. Preferably a plurality of chambers 36 are simultaneously in communication with the interior of the hopper, and Figure 4 shows by way of example a situation where seven such chambers are in communication. To prevent a leakage of powder from the chambers 36 while they are in communication with the interior of the hopper, a seal 72 surrounds the opening 70, and the lower surface of the wheel 20 is in sliding contact with the seal 72. In order to reduce wear on the lower plate 24 at least the portion thereof in contact with the seal 72 is coated with a suitable material such as stainless steel impregnated with polytetrafluoroethylene. The ends of the opening 70 are sealed by conventional doctor blades (not shown).

In use, the shaft 26 is continuously rotated at a constant speed and as chambers 36 come above the opening 70 the vacuum applied to the channel 40 causes powder to be drawn into the chambers. Vacuum continues to be applied after the chambers are no longer above the opening 70, so as to hold in each of the chambers a plug of powder. As each chamber passes below the channel 46 in the plate 38, vacuum ceases to be applied and instead air, nitrogen or carbon dioxide, for example, at above atmospheric pressure enters the chamber. This causes the plug of powder in the chamber to be discharged into the vial 62 located below the chamber. If desired, means (not shown) may be provided for discharging air into each chamber after a plug of powder has been discharged therefrom. This serves to clean the chamber. A vacuum extraction system is then preferably provided to collect any powder blown out of the chambers.

It will be appreciated that as the wheel 20 is rotated continuously and at a constant speed the number of containers filled per unit time can be greater than with the conventional machine described above with reference to Figures 1 and 2 where the filling wheel is indexed. Thus, the invention can provide for operating speeds of from 25 to 500 vials per minute. Furthermore, the need for a sophisticated timing mechanism is eliminated. Each container is transported in alignment with a respective chamber so that the precise moment at which powder is discharged from the chamber is not critical. It should also be noted that the use of an arcuate opening 70 enables each chamber to be in communication with the hopper for a substantial period of time, thus ensuring that each chamber is completely filled. This is particularly important where the machine is being used for application such as in the pharmaceutical field, where it is important to achieve a constant and predetermined dose of powder in each container. It should be noted that though the speed at which the machine operates is preferably constant, this speed can be adjusted to meet different filling demands.

It may be desired to use the machine of the present invention to introduce into a container a larger quantity of powder than can be conveniently transferred direct into the container in one dose. A method of introducing large doses into vials is provided by the embodiments which are shown in

Figures 7 and 8. In these embodiments each chamber 36 is replaced by a set of several chambers 36'. Figure 7 shows sets of three chambers 36', and Figure 8 shows sets of two chamber 36'. As illustrated, in each set the chambers are disposed along a line which is at an acute angle to a radius, though they may alternatively be disposed along a radius. The magazine carries each vial 62 in an elongate slot 80 which is indicated by broken lines in Figures 7 and 8. The slots 80 are arranged at the same angle to a radius as are the rows of chambers 36' so that the vial in each slot can register with one of the chambers.

Each vial is fed to the magazine 60 and initially adopts the radially innermost position, indicated by reference A in Figure 7. As the filling wheel rotates a first plug of powder is discharged from the radially innermost chamber 36' in the set of three into the vial. A stationary curved guide rail 82 is provided which, as the filling wheel and magazine continue to rotate, guides the vial outwardly along slot 80. It will be seen that when the vial reaches position B a second plug of powder can be discharged into it from a second chamber 36' in the set of three. Upon continued rotation of the magazine 60 the rail 82 guides the vial into position C, in which a third plug of powder is discharged from a third chamber 30'.

Plugs of powder are introduced simultaneously into three vials in three different slots 80, since when one vial is at position A another has reached position B (having already received one plug of powder at position A) and another is at position C having already received plugs of powder at positions A and B. If provision is made, as mentioned above, for introducing air into the chambers to clean them, this may be done at the location indicated by Y.

The procedure with the filling wheel of Figure 8 is the same as the procedure with the filling wheel of Figure 7, except that only two plugs of powder are discharged into each vial.

The configuration of the channels 40 and 46 in the top plates 38 of the filling machine described in relation to Figures 3, 7 and 8 will now be considered in detail. Plan views of the relevant plates 38 are shown in Figures 9, 10 and 11 respectively.

As shown in Figure 9, the plate 38 for the embodiment of Figure 3 has an arcuate channel 40 extending around approximately 180°. As discussed above, the channel 40 communicates with a source of vacuum. As the filling wheel 20 and magazine 60 rotate, chambers 36 are continuously coming into and out of communication with the channel 40. While in communication with the channel, the chambers are filled with powder from the hopper 64 arranged below. Shortly after coming out of communication with the channel 40, the chambers in turn communicate with the channel 46 which causes the powder to be discharged into the vial 62 below the chamber which has been rotating in unison therewith. Further rotation brings each chamber in turn into communication with a port cleaning slot 47, the function of which has been explained above.

As shown in Figures 10 and 11, the configuration of the channels 40 and 46 for the embodiments of Figures 8 and 9 is similar to that shown in Figure 9, except that three and two sets of channels respectively are provided for communication with the sets of three and two chambers 36'. The air discharge channels 46 are staggered around the circumference so that at a given moment powder is being discharged into three vials 62 in the positions A, B and C, taking Figure 7 as an example.

The appropriate number of port cleaning slots 47 are also provided.

In a further embodiment of the invention, which provides another way of introducing a larger or varied dose of powder into a vial, a plurality of filling wheels (say two or three) is provided, each receiving powder from the same hopper, or different hoppers, with the vials passing successively from one filling wheel to the next to receive a dose of powder from each. An example of such an embodiment is illustrated Figure 12.

The figure shows two hoppers 64A, 64B each feeding two filling wheels 20. Vials are passed between the filling wheels by rotating vial transfer magazines 90. The path of the vials is shown by the dashed line 92. The dosing position for each wheel 20 is indicated by the letter F.

Each vial thus receives four doses of powder in total, two from hopper 64A and two from hopper 64B. The material A in the first hopper may be the same as or different from the material B in the second hopper.

Claims

1. A machine for introducing a quantity of powder into a plurality of containers (62), comprising a powder transporting member (20) mounted on a substantially vertical axis and having a plurality of downwardly open chambers (36), a container transporting member (60) located below the powder transporting member (20), means for continuously rotating the powder transporting member (20) about the substantially vertical axis, a reservoir (64) for powder with which the said chambers (62) communicate during part of the rotation of the powder transporting member (20), means (40) for applying vacuum to the chambers (36) to cause powder to be drawn therein, and means (46) for discharging the powder from each chamber (36) into a

container (62) carried by the container transporting member (60),

characterized in that the container transporting member (60) is mounted on the same substantially vertical axis as the powder transporting member (20) for continuous rotation therewith, that the reservoir (64) is located at least in part between the powder transporting member (20) and the container transporting member (60), that a plurality of the chambers of the powder transporting member (20) communicate at any one time with the reservoir along an arcuate communication path, that the powder transporting member (20) is mounted on the substantially vertical axis for rotation in a single, substantially horizontal plane, and that means are provided to deliver and remove containers (62) to and from the container transporting member (60) either side of the reservoir (64).

2. A machine according to claim 1, wherein the powder transporting member comprises a plurality of sets of at least two chambers (36') and wherein means (82) are provided for successively locating each container under a different chamber of each set as the transporting members are rotated.

3. A machine according to claim 2, wherein the said locating means (82) comprises fixed guide rail and wherein the container transporting member (60) comprises a plurality of slots (80) along which the containers are guided by the said rail (82) during rotation.

4. A machine according to any preceding claim, wherein the volume of each chamber is adjustable between 85 and 3142 mm^3.

5. A machine according to any preceding claim, comprising twenty-four of the said chambers.

6. An arrangement comprising at least two machines according to claim 1, wherein the machines communicate with a common reservoir for powder.

7. An arrangement comprising at least two machines according to claim 1 and means for transferring containers from the container transporting member of one machine to the container transporting member of the or each other machine.

8. An arrangement according to claim 11 comprising at least two pairs of machines, each of said pairs of machines having a common powder reservoir.

Patentansprüche

1. Maschine zum Einfüllen einer Pulvermenge in mehrere Behälter (62), mit einem Pulvertransportteil (20), das an einer im wesentlichen vertikalen Achse montiert ist und mehrere nach unten hin offenen Kammern (36) aufweist, einem unterhalb des Pulvertransportteils (20) angeordneten Behältertransportteil (60), einer Einrichtung zum kontinuierlichen Drehen des Pulvertransportteils (20) um die im wesentlichen vertikale Achse, einem für Pulver vorgesehenen Reservoir (64), mit dem die Kammern (62) während eines Teils der Drehung des Pulvertransportteils (20) in Verbindung stehen, einer Einrichtung (40), die die Kammern (36) zum Einsaugen von Pulver in diese einem Unterdruck aussetzt, und einer Einrichtung (46) zum Ausgeben des Pulvers aus jeder Kammer (36) in einen von dem Behältertransportteil (60) gehaltenen Behälter (62),
dadurch gekennzeichnet, daß das Behältertransportteil (60) zur kontinuierlichen Drehung mit dem Pulvertransportteil (20) an derselben im wesentlichen vertikalen Achse montiert ist wie das Pulvertransportteil (20), daß das Reservoir (64) mindestens teilweise zwischen dem Pulvertransportteil (20) und dem Behältertransportteil (60) angeordnet ist, daß mehrere Kammern des Pulvertransportteils (20) zu jeder Zeit längs eines bogenförmigen Verbindungsweges mit dem Reservoir in Verbindung stehen, daß das Pulvertransportteil (20) zur Drehung in einer einzigen, im wesentlichen horizontalen Ebene an der im wesentlichen vertikalen Achse montiert ist, und daß Einrichtungen vorgesehen sind, die zu beiden Seiten des Reservoirs (64) Behälter (62) zu bzw. von dem Behältertransportteil (60) zuführen und abnehmen.

2. Maschine nach Anspruch 1, bei der das Pulvertransportteil mehrere Sätze von mindestens zwei Kammern (36') aufweist und bei der Einrichtungen (82) vorgesehen sind, die jeden Behälter sukzessiv unter einer anderen Kammer jedes Satzes positionieren, während die Transportteile gedreht werden.

3. Maschine nach Anspruch 2, bei der die Positioniereinrichtung (82) eine fest montierte Führungsschiene aufweist und bei der das Behältertransportteil (60) mehrere Schlitze (80) aufweist, längs derer bei Drehung die Behälter von der Schiene (82) geführt werden.

4. Maschine nach einem der vorhergehenden Ansprüche, bei der das Volumen jeder Kammer zwischen 85 mm^3 und 3142 mm^3 einstellbar ist.

5. Maschine nach einem der vorhergehenden Ansprüche, mit vierundzwanzig der Kammern.

6. Anordnung mit mindestens zwei der Maschinen nach Anspruch 1, bei der die Maschinen mit einem gemeinsamen Pulverbehälter verbunden sind.

7. Anordnung mit mindestens zwei der Maschinen nach Anspruch 1 und einer Einrichtung zum Tranferieren von Behältern von dem Behältertransportteil einer Maschine zu dem Behältertransportteil der oder jeder weiteren Maschine.

8. Anordnung nach Anspruch 11, mit mindestens zwei Paaren von Maschinen, wobei jedes der Paare von Maschinen ein gemeinsames Pulverreservoir aufweist.

Revendications

1. Machine pour introduire une quantité de poudre dans une pluralité de récipients (62), comprenant un organe de transport de poudre (20) monté sur une axe sensiblement vertical et présentant une pluralité de chambres (36) ouvertes vers le bas, un organe de transport de récipient (60) situé au-dessous de l'organe de transport de poudre (20), un moyen pour faire tourner de manière continue l'organe de transport de poudre (20) autour de l'axe sensiblement vertical, un réservoir (64) pour contenir de la poudre, avec lequel lesdites chambres (62) communiquent durant une partie de la rotation de l'organe de transport de poudre (20), un moyen (40) pour appliquer du vide aux chambres (36) pour provoquer le placement de la poudre dans ces dernières, et un moyen (46) pour décharger la poudre depuis chaque chambre (36), pour aller dans un récipient (62) supporté par l'organe de transport de récipient (60),

   caractérisée en ce que l'organe de transport de récipient (60) est monté sur le même axe sensiblement vertical que l'organe de transport de poudre (20), pour tourner de manière continue avec ce dernier, en ce que le réservoir (64) est situé au moins partiellement entre l'organe de transport de poudre (20) et l'organe de transport de récipient (60), en ce qu'une pluralité des chambres de l'organe de transport, de poudre (20) communique à tout moment avec le réservoir, le long d'un chemin de communication arqué, en ce que l'organe de transport de poudre (20) est monté sur l'axe sensiblement vertical pour tourner dans un unique plan sensiblement horizontal, et en ce que des moyens sont prévus pour fournir et retirer des récipients (62) à, et depuis l'organe de transport de récipient (60), sur un côté quelconque du réservoir (64).

2. Machine selon la revendication 1, dans laquelle l'organe de transport de poudre comprend une pluralité de jeux d'au moins deux chambres (36'), et dans laquelle des moyens (82) sont prévus pour positionner successivement chaque récipient sous une chambre différente de chaque jeu, lorsque les organes de transport sont entraînés en rotation.

3. Machine selon la revendication 2, dans laquelle ledit moyen de positionnement (82) comprend un rail de guidage fixe, et dans laquelle l'organe de transport de récipient (60) comprend une pluralité de fentes (80) le long desquelles les récipients sont guidés par le rail de guidage (82) durant la rotation.

4. Machine selon l'une quelconque des revendications précédentes, dans laquelle le volume de chaque chambre est ajustable à une valeur comprise entre 85 et 3142 mm^3.

5. Machine selon l'une quelconque des revendications précédentes, comprenant lesdites chambres en un nombre de vingt-quatre.

6. Agencement comprenant au moins deux machines selon la revendication 1, dans lequel les machines communiquent avec un réservoir commun pour de la poudre.

7. Agencement comprenant au moins deux chambres selon la revendication 1 et un moyen pour transférer les récipients depuis l'organe de transport de récipient d'une machine, à l'organe de transport de récipient de la machine ou de chaque autre machine.

8. Agencement selon la revendication 11, comprenant au moins deux couples de machines, chacun desdits couples de machines présentant un réservoir de poudre commun.

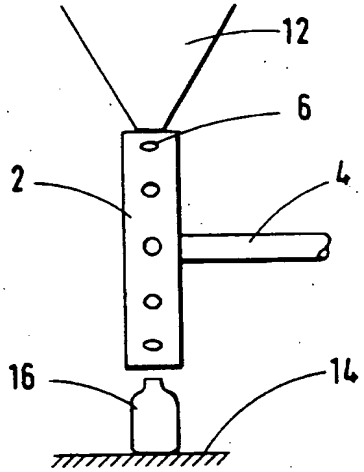

Fig.1

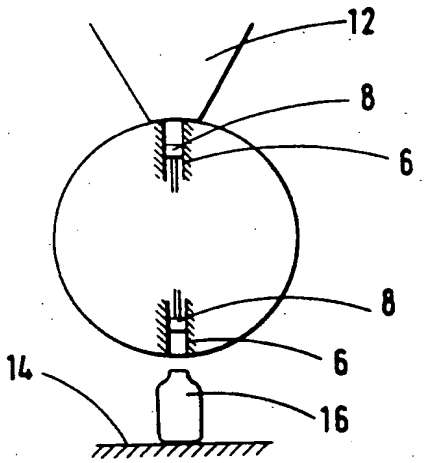

Fig. 2

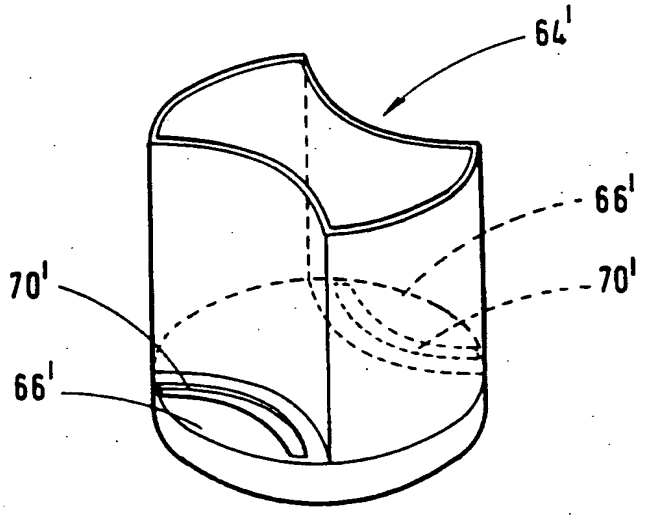

Fig. 6

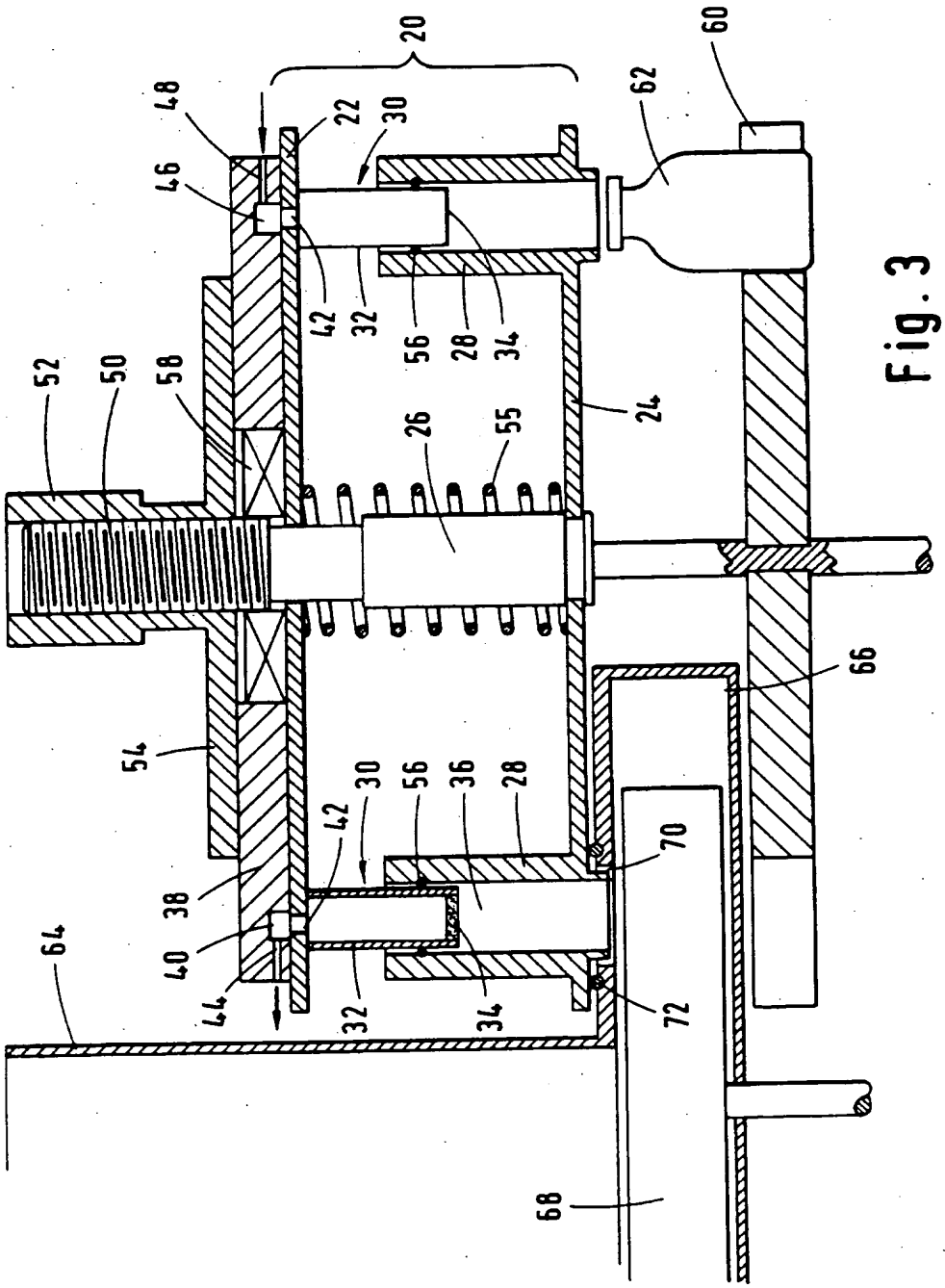
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Fig. 3

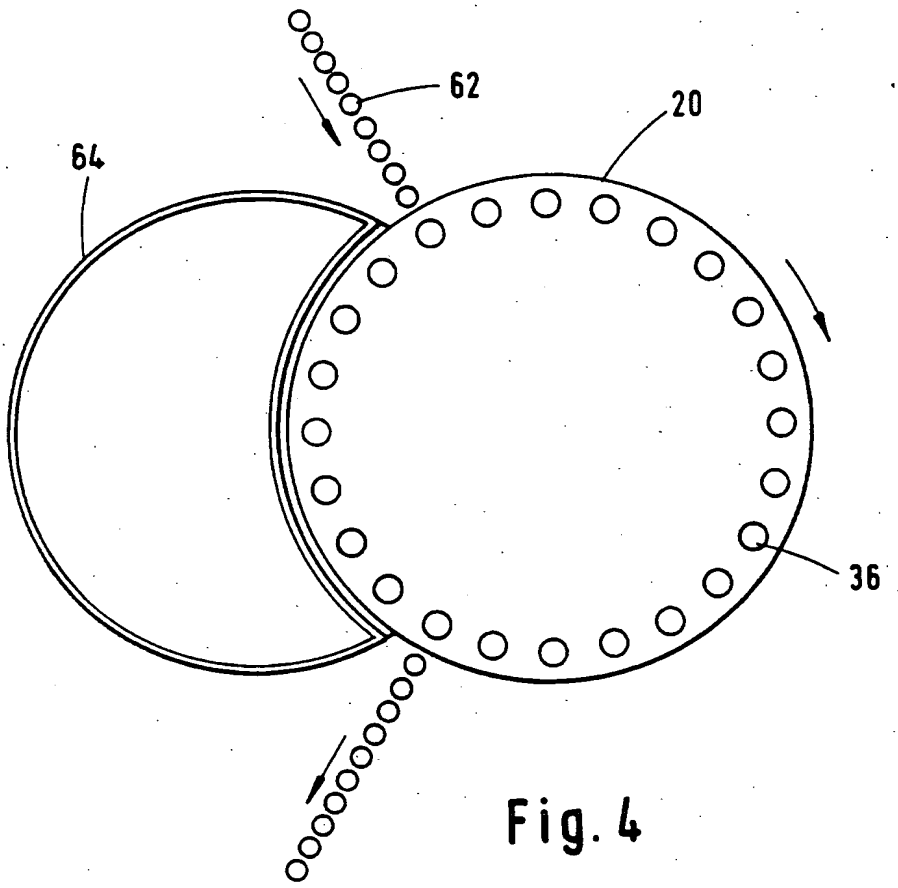

Fig. 4

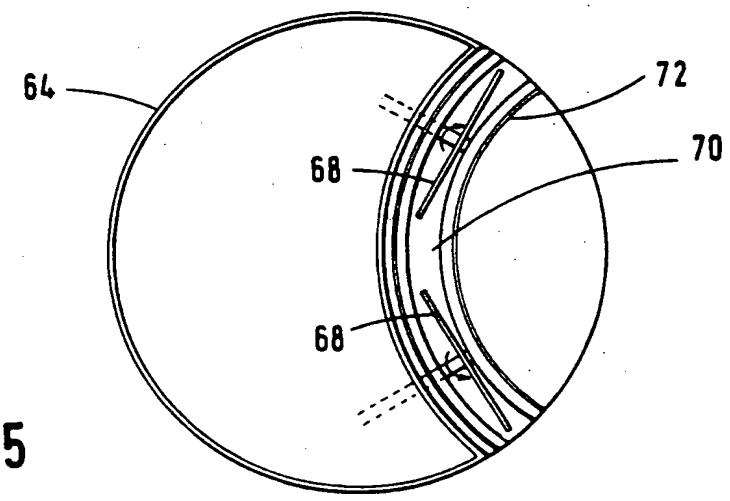

Fig. 5

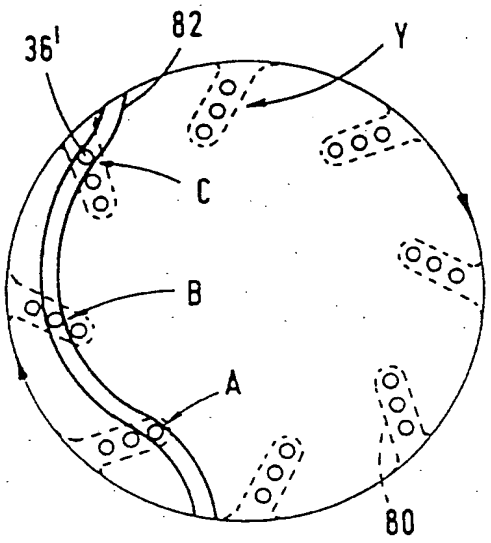

Fig. 7

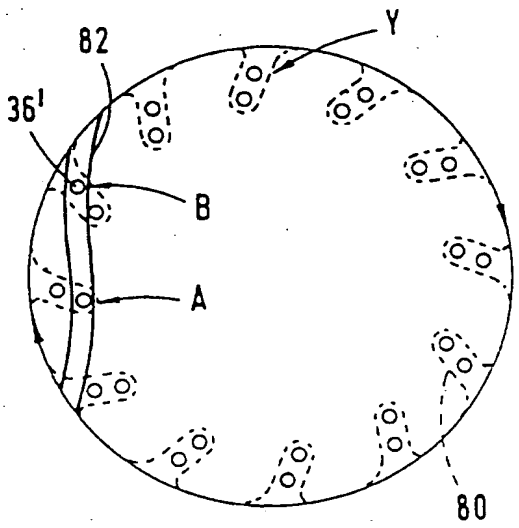

Fig. 8

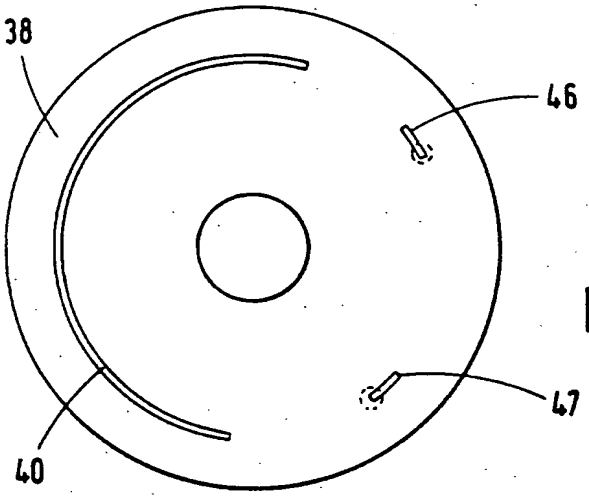

Fig. 9

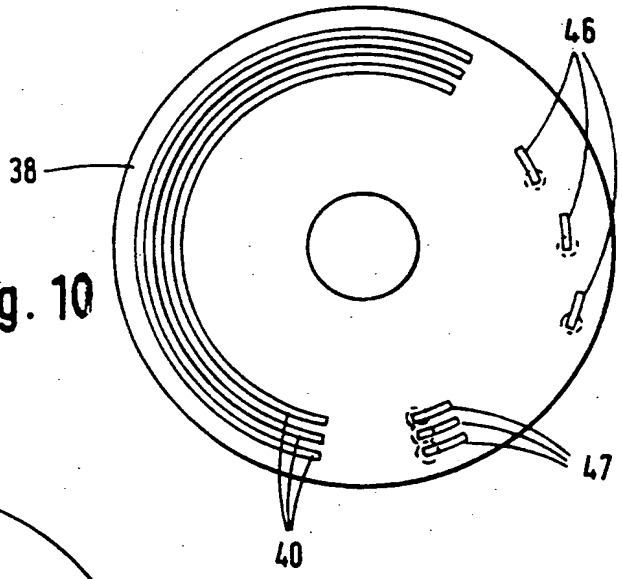

Fig. 10

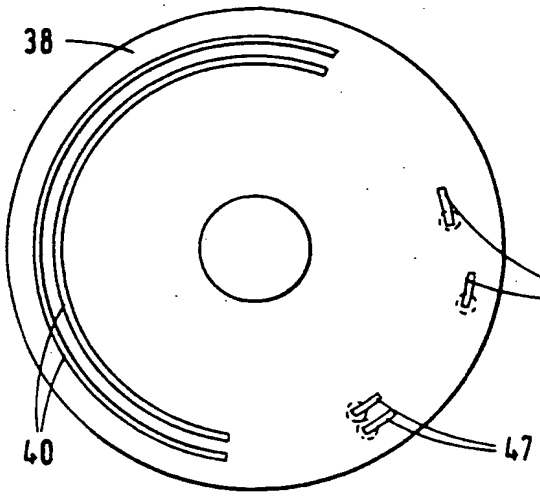

Fig. 11

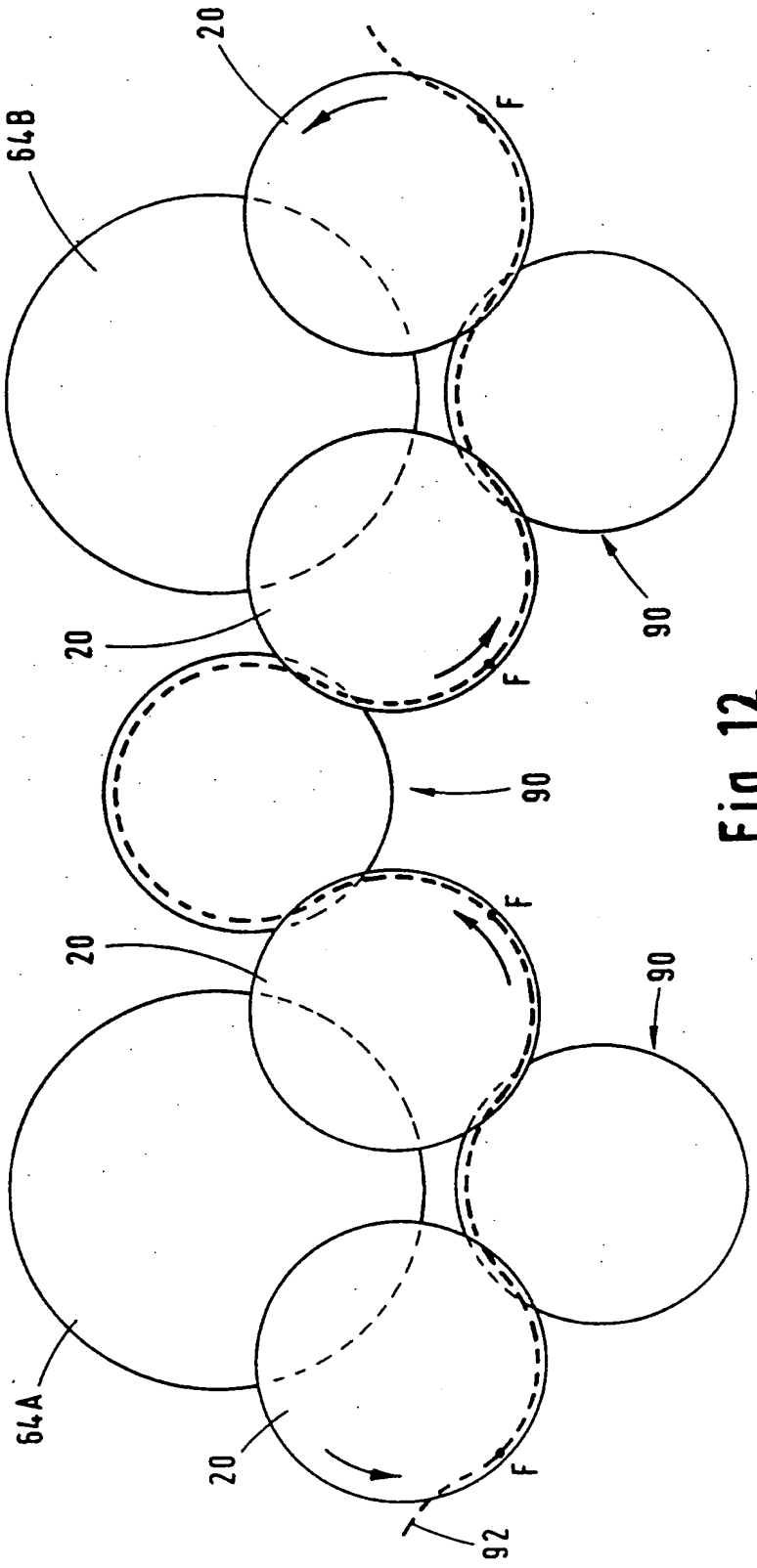

Fig. 12